

**BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR FLOOD PROTECTION
AND DRAINAGE IMPROVEMENT
IN THE MUNICIPALITY OF PHNOM PENH
(PHASE II)
IN
THE KINGDOM OF CAMBODIA**

October 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

**CTI ENGINEERING INTERNATIONAL CO., LTD.
in association with
NIPPON KOEI CO., LTD.**

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Department of Public Works and Transport
Municipality of Phnom Penh
Kingdom of Cambodia

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PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team from January 10 to February 22, 2006.

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

October 2006

Masafumi KUROKI
Vice-President
Japan International Cooperation Agency

October 2006

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II) in the Kingdom of Cambodia.

This study was conducted by the consortium of CTI Engineering International Co., Ltd. and Nippon Koei Co., Ltd., under a contract to JICA, during the period from December 2005 to October 2006. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Masakazu MAEDA

Project Manager
Basic design study team on
the Project for Flood Protection
and Drainage Improvement
in the Municipality of Phnom Penh
(Phase II) in the Kingdom of Cambodia

The Consortium of
CTI Engineering International Co., Ltd.
and Nippon Koei Co., Ltd.

SUMMARY

1. Outline of Cambodia

With an area of 181,000 square kilometers, the Kingdom of Cambodia had the population of about 1.38 million in 2004. Gross National Income (GNI) per capita of Cambodia is US\$ 350. The climate of Cambodia is classified as tropical monsoon type, characterized by two seasons: dry and rainy season. The rainy season is normally from May to November.

After decades of civil wars, Cambodia started to reconstruct the country in the 1990's under a new coalition government with a market economy system. With the assistance of the international community, the Cambodian government has been actively promoting administrative and financial reforms and development of infrastructures. Gross Domestic Product (GDP) growth rates exceeded 7% per year in 1991 and 1992. After a slowdown from 1993 to 1994, the economy expanded at high rate at 7.6% per year in 1995. The growth in 1996 was reduced by damage by floods from September to October, leading to drop in crop production. Until 1996, the engine for fast GDP growth were such sectors and sub-sectors as the manufacturing and service sector.

2. Background of the Project

The construction of outer ring dikes for the protection of Phnom Penh City from flooding of neighboring rivers, lakes and swamps had started since the 1960's, and urban drainage facilities with functions of draining storm water and domestic wastewater were improved gradually according to the development of the city. However, all of the drainage facilities, which have been constructed since the beginning of the 1900's, are not functioning well due to old age, as well as poor maintenance after the 1970's. As a result, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in lowland areas. These are serious constraints to the residents' living environment as well as social and economic development, not only of Phnom Penh City but the whole country in general.

The Government of Cambodia (GOC) had made a request for technical cooperation from the Government of Japan to formulate a Master Plan for the flood protection and urban drainage improvement in Phnom Penh City and suburbs. In response, the Government of Japan (GOJ) had dispatched a study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to formulate the Master Plan and to conduct a Feasibility Study on priority projects selected from the Master Plan. That study was conducted from March 1998 to August 1999.

Based on these priority projects, “The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh” was carried out under the Japan’s Grant Aid Scheme from 2001 to 2004. This project included improvement of drainage channels and construction of a new pumping station focusing on improvement of southwest area of the city. Although drainage conditions in southwest area of the city have greatly improved, the city center and eastside of the city, such as the Central Market, Royal Palace, Wat Phnom and Trabek area, has been still flooded in a rainy season. The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II) was therefore requested in July 2004 by the Cambodian Government to implement the remaining priority projects.

The Government of Cambodia (GOC) requested Japan’s Grant Aid assistance consisting of facility construction works as follows.

Revetment Works for Tonle Sap River (Longitudinal Length: 1.5 km)

Improvement of Wat Phnom Area (Drainage Pipe: 9.05 km, Pumping Station: 1 station, Underground Reservoir: 1 location)

Improvement of Central Market Area (Drainage Pipe: 3.4 km, Pumping Station: 2 stations, Underground Reservoir: 3 locations)

Improvement of Royal Palace & National Museum Area (Drainage Pipe: 0.7 km, Pumping Station: 2 stations, Underground Reservoir: 2 locations)

Improvement of Road Drainage System and Road Rehabilitation in Trabek Basin and Adjacent Area (Drainage Pipe: 19.0 km, Rehabilitation of Road Pavement: 200 ha)

Procurement of Maintenance Equipment of Drainage System (1 set: Sludge Vacuum Loader, High Water Pressure Jetting Machine)

3. Outline of the Study and Contents of the Project

3.1 Study Schedule

JICA dispatched the Basic Design Study Team from 10 January to 22 February 2006. In the Basic Design Study, the urgency and necessity of the requested project were again recognized. The content and size of the Project, as well as its appropriateness and effect have been discussed and proposed in the draft of the Basic Design Study Report, which was explained to the Cambodia side by an explanation team dispatched to Cambodia from October 8 to 13, 2006. Both sides had agreed on the contents and the finalization of the Basic Design Study Report.

3.2 Outline of the Study

(1) Maintenance Equipment of Drainage System

Maintenance equipment of drainage pipe plays an important role in demonstrating the adequate function of a drainage system composed of drainage pipes and pumping stations. Though the maintenance equipment that DPWT presently possess are old and work efficiency is bad, it is considered that those maintenance equipment are in the state that can be used if it is maintained well. Therefore, it is judged that there is no necessity to supply new maintenance equipment urgently by Japan's Grant Aid. However, even if excellent maintenance of the existing equipment is continued, interference in the maintenance work on the drainage network should be expected in the next five years because the existing equipment are very old and some of them have already exceeded their service life.

(2) Flood Protection Plan

As the Flood Protection Plan, rehabilitation and improvement of revetment shall be implemented. The study area for revetment improvement is the stretch of Chroy Changvar Bridge (Cambodia-Japan Friendship Bridge) up to the Chakto Mukh National Theater. There are two (2) sections of revetment that are seriously damaged and MPP have strongly requested the improvement of these sections. Therefore, the following two (2) sections of revetment are selected as the objective sections of the Project.

(a) Old Market East Revetment: This section is located at the eastern side of the old market in the downstream side of Road No. 108 along the Tonle Sap River. The dike in this section had slid and 100 m of the existing revetment had collapsed.

(b) Chakto Mukh National Theater Revetment: This section of 70 m in length is located in the upstream from the boundary of Chakto Mukh National Theater and Himawari Hotel. Some portions of the revetment in this section have been damaged or had collapsed.

(3) Drainage Improvement Plan

The requested study area divided the study area into two (2) major areas. The north area (Wat Phnom Area, Central Market Area and Royal Palace & National Museum Area) projects, particularly, the construction of new pumping stations, are required based on geographical characteristics. Based on the technical know-how in Cambodia, it will be difficult for them to install mechanical and electrical equipment of pumping stations and to construct underground reservoirs, which is a large structure. Therefore, it is necessary for projects of the north area to be implemented under Japan's Grant Aid.

On the other, the projects of south area (Trabek Basin and Adjacent Area) consist of improvement of drainage system, rehabilitation of road pavement and installation of side ditch. These projects do not need special technology from Japan or a foreign country and, conventionally, the Cambodian Government has carried out such projects in the past. In this basic design, the layout and design of drainage pipes required for the drainage improvement in this area was clarified. Therefore, if funds are obtainable, the Cambodian Government will be able to undertake these projects by itself.

As mentioned above, when the projects of the north and south areas are compared, the north area projects have a higher priority. All projects were evaluated as to the existence of important installations, relevance with other projects, and beneficial and adverse effects. The results of evaluation, Wat Phnom Area, Central Market Area and Royal Palace & National Museum Area are selected as the objective areas of the Project.

(4) Interceptor Plan

This plan was not included in the contents of the Request at the beginning. However, wastewater flows directly into the Tonle Sap River and the river is much polluted by untreated wastewater. Therefore, the interceptor system shall be proposed in this project and the wastewater collected through the drainage networks shall be transported to the Trabek Main Canal through the interceptor. Interceptor is installed alongside Tonle Sap River and the total length of interceptor pipe is approximately 1.8 km.

3.3 Basic Concept of the Project

In the basic design study, the following basic design policies have been considered in the construction of facilities.

Item		Policies / Points of Consideration
Natural Conditions	Design High Water Level of Tonle Sap River	The design high water level of Tonle Sap River for revetment design and pumping design is set at EL. 10.20 m based on the recorded highest water level of EL. 10.18m at Chakto Mukh water level gauge on 20 September 2000.
	Drainage Facilities	The protection level for drainage facilities, which corresponds to 2-year return period is adopted in accordance with the Master Plan
Socio-Economic Conditions		Acquisition of private land and house relocation attendant on the Project implementation often cause social conflicts. Therefore, It formulates the plan which does not need these in this project.
		The implementation plan of construction works shall give particular attention on noise and vibration pollution and the minimization of negative impact on economic activities.
Construction/ Procurement	Design Standard	The structural design standards in Cambodia have not been established yet. Since previous Japan's Grant Aid projects have adopted Japanese design standards, this study had also adopted the Japanese design standards.

	Procurement Situation	Main construction materials like cement, reinforcing bars, aggregates and so on are available in Cambodia, but the local availability of particular construction components like steel gate, drainage pump, electric facilities and so on is difficult. Locally available materials shall be used for the construction as much as possible to minimize the construction cost. The Study had also considered the future improvement plan to avoid the duplication of investment.
	Related Law/Regulation	The approval of MPP is required also for the execution of various constructions in public spaces. Since the superintendence organization of this Project is MPP, there is no obstacle in project execution.
	Construction Supervisor for Installation of Pump, Machinery and Electric Equipment	Some local engineers capable of supervising general construction work are available in the Phnom Penh City, but local engineers knowledgeable in the installation of the pump, machine and the electrical equipment procured under the Project are not available. Construction supervisors for such special installation work shall be dispatched separately from Japan.
Applicability of Cambodian Company		There are some local contractors in Cambodia, and they have experience in construction works involving Japan's Grant Aid Project. Therefore, local contractors could be used for the general construction components to reduce the construction cost.
Operation and Maintenance Condition of Implementing Agency		To determine the adequate specifications of the objective facilities, the capabilities and budget for operation and maintenance of the implementing agency shall be considered in the Basic Design Study.
Determination of Planning Scale of the Objective Facilities	Flood Protection Plan	Existing revetment shall be reinforced to make it safe from the recorded highest water level of the Mekong and Sap rivers, which corresponds to about 30-year probability of planning scale.
	Drainage Improvement Plan	Drainage facilities, such as drainage pipe, underground reservoir and pumping station, shall also be improved with the planning scale of 2-year probability to be able to drain the storm water within 1 to 2 hours with 20 cm of allowable inundation depth. The sites of new pumping stations are limited and located in scenic areas so that the size of pumping stations shall be minimized as much as possible. With the situation taken into consideration, an underground reservoir is planned next to a pumping station as a retarding pond of a pumping station to reduce the pumping capacity as much as possible and to minimize cost of the pumping equipment.
Implementation/ Procurement Plan and Implementation Schedule		The construction works are easily affected by rain and flooding. During the rainy season, work efficiency certainly becomes low and work progress will decline as a result. Therefore, it is important to consider the rainy season in the establishment of the implementation plan as well as the procurement plan. The construction of revetment and underground reservoir that faces the river and adjoining areas shall be executed mainly in the dry season.
		In consideration of construction scale and work efficiency in the rainy season, it is estimated that the term of construction would require three (3) dry seasons. To establish the implementation schedule, the conditions mentioned above shall be considered.

3.4 Contents of the Project

Based on the above considerations, the agreed facility have been identified through the field survey in Cambodia and the technical examination in Japan.

Summary of Facility Design

Item	Area	Components	Quantity	Specification
Flood Protection Plan	Chakto Mukh Theater Revetment	Revetment Works	70 m	
	Old Market East Revetment	Revetment Works	260 m	
Drainage Improvement Plan	Wat Phnom Area	Drainage Pipe	1,115 m	371 m, 1,200 mm (R51) 190 m, 1,000 mm (R19) 554 m, 1,500 mm (R19)
		Side Ditch	320 m	160 m, B500 mm × H650 mm 160 m, B500 mm × H750 mm
	Central Market Area	Drainage Pipe	2,216 m	539 m, 1,000 mm (Norodom) 644 m, 1,500 mm (R154) 211 m, 1,500 mm (R148) 454 m, 1,000 mm (Monivong) 358 m, 1,200 mm (R110) 10 m, 1,800 mm (R108)
		Pumping Station	2 stations	5,000 m ³ /h (1.4 m ³ /s) (P4) 5,000 m ³ /h (1.4 m ³ /s) (P5)
		Underground Reservoir	2 locations	6,480 m ³ (UGR3 & UGR4) 2,475 m ³ (UGR5)
	Royal Palace & National Museum Area	Drainage Pipe	726 m	1,800 mm (R240) 1,500 mm (R178)
		Pumping Station	2 stations	5,000 m ³ /h (1.4 m ³ /s) (P1) 2,500 m ³ /h (0.7 m ³ /s) (P2)
		Underground Reservoir	2 stations	870 m ³ (UGR1) 1,200 m ³ (UGR2)
	Interceptor Plan	Interceptor Plan	Interceptor Pipe	1,818 m

4. The Implementation Period and Project Cost

The implementation period of this Project is estimated to be 7.5 months for detailed engineering design, and 30 months for installation and facility construction including the equipment procurement. The project to be completed under the Japan's Grant Aid scheme is estimated to cost JPY 2,668 million (i.e., Yen 2,664 million from GOJ and JPY 4 million from GOC).

5. Project Evaluation and Recommendations

5.1 Project Effect

The following direct benefits are expected:

Flood Protection

With the improvement, safety against flooding of a 30-year probability can be assured.

About 120,000 units of households, 460,000 residents, 7,600 units of factories, shops and offices and 100 units of schools and hospitals will be safety from flood.

Drainage Improvement

With the improvement of drainage facilities with a planning scale of 2-year flood probability, drainage of storm water with inundation depths of 20 cm will be possible within 1 to 2 hours.

The frequency of flooding will be reduced.

Flood damage by more than a 2-year flood probability will be mitigated.

The implementation of the Project will also reduce the number of damage by inland water inundation to 34,000 units of residential houses, 40,000 units of households, 120,000 citizens, 3,000 units of factories, shops and offices, and 50 units of school and hospitals.

Interceptor Planning

Wastewater of about 9,000 tons/day will not flow directly into the river. In this Project, the influence with respect to water quality is converted into BOD concentration. BOD₅ of the sewage discharged in the present condition is 100 mg/L. Therefore, the discharge of 900 kg of BOD₅ is controlled per day, and the pollution situation of Tonle Sap River improves greatly.

In addition, the following indirect effects are expected:

The Project will contribute to avoid the occurrence of economic damage because the project area encompasses commercial, tourist and public office areas.

As the indirect effect of the improvement of urban drainage facilities in the Project, the prevention of occurrence and spread of epidemics due to long duration of inundation is expected.

Inundation periods will become shorter and inundation depths will become shallower, making it easier for ordinary vehicles to pass the roads.

5.2 Recommendations

Before the Commencement of Construction Work

- The resident's opinion shall be taken into consideration, and it is necessary to facilitate the understanding and cooperation of the inhabitants on project implementation.

- Land acquisition for the construction area, stock-yard, work yard, warehouse, site office, workshop and disposal area shall be given first priority.

During Construction Work

- Environmental impact mitigation measures and environmental monitoring program shall be executed based on the result of Initial Environmental Examination (IEE). Since the construction works are to be conducted in dense residential areas, noise, vibration or traffic accident by construction equipment during the construction period shall be prevented. It is also necessary to take measures to prevent dropping of excavated materials from carriers and the dispersal of soil adhering to the tires of transport vehicles during transportation.
- Inundation of the work area might take place even in the dry season and wastewaters flow into the construction area. Therefore, temporary facilities and measures for dewatering shall be planned and enforced.
- Since the construction work on revetment will be affected greatly by the water level of the Tonle Sap River, the construction plan shall consider the seasonal variation of water level, and it will be necessary to observe changes in the water level to prevent accidents and disaster occurrence.

After Construction Work

- Environmental monitoring program shall be executed based on the result of Initial Environmental Examination. Erosion of dike, riverbed scouring of Tonle Sap River, sedimentation of silt and weeding on revetment shall be monitored. Especially, dike erosion and riverbed scouring shall be monitored carefully. If those transformations of river shape are observed, necessary counter measures shall be taken promptly.
- Appropriate operation, maintenance and management of the planned, designed and completed flood protection and drainage facilities are indispensable to bring them fully functional. Enough number of staff and budget are thus important for the purpose.
- The existing equipment are very old and some of them have already exceeded their service life. The Municipality of Phnom Penh (MPP) is thus required to allocate the necessary budget and disburse it for the rehabilitation or overhauling of maintenance equipment.
- Investigations and analyses are needed to establish the flood protection plan to secure a long-term safety against flood in the future. The following investigations and analyses are strongly recommended:

- (a) Topographic survey of river shape, alignment and cross-sections at the confluence of the Tonle Sap River and Mekong River, and hydraulic analysis; and
 - (b) Hydrological investigation of flow volume, flow velocity and flooding duration at the confluence of the Tonle Sap River and the Mekong River under flooding condition, and hydraulic analysis.
- The fundamental measure for solving a drainage problem is to carry out all of the drainage plans including drainage mains and laterals, and an effective drainage plan is not realized in a partial plan. Therefore, to be able to attain an impressive target in the whole city area, a suitable operation and maintenance plan and drainage lateral plan are required to be carried out gradually and intentionally. It should be noted that the drainage system in the area north of Wat Phnom and the area west of the Royal Palace differs from the drainage system in this Project, so that these areas will not receive the effect of this Project so easily. Therefore, it seems that it is necessary to venture on a more comprehensive improvement as soon as possible. The project for the Trabek Basin and the adjacent area will not be undertaken at the same time as the Project. Since there is a possibility that flood damage in these areas will expand under the present condition, a drainage improvement project for the area should be undertaken immediately.

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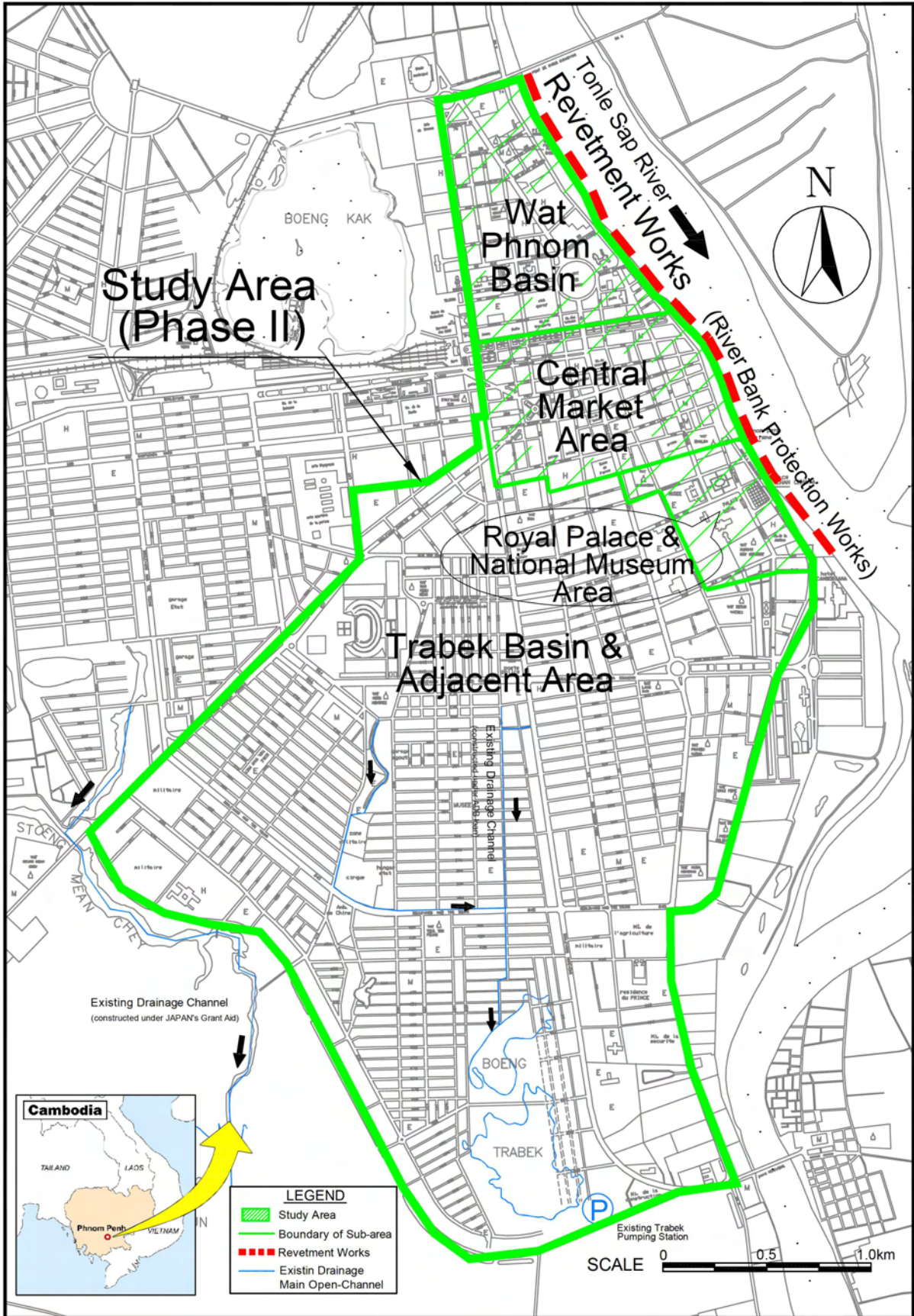
TABLE OF CONTENTS

Preface	
Letter of Transmittal	
Summary.....	i
Table of Contents.....	x
Location Map / Perspective.....	xii
List of Tables & Figures	xv
Abbreviations.....	xix
CHAPTER 1 BACKGROUND OF THE PROJECT	1-1
1.1 Background of the Project	1-1
1.2 Contents of the Request	1-2
1.3 Present Condition of the Project Area	1-3
1.3.1 Natural Condition	1-3
1.3.2 Underground Facilities Survey.....	1-11
1.3.3 Inundation Condition Survey in South Area.....	1-13
1.3.4 Inundation Condition Survey in North Area.....	1-22
CHAPTER 2 CONTENTS OF THE PROJECT	2-1
2.1 Basic Concept of the Project	2-1
2.1.1 Overall Goal and Project Objective.....	2-1
2.1.2 Basic Concept of the Project.....	2-2
2.2 Basic Design of the Requested Japanese Assistance	2-3
2.2.1 Design Policy	2-3
2.2.2 Basic Plan.....	2-9
2.2.3 Basic Design.....	2-26
2.2.4 Basic Design Drawing	2-60
2.2.5 Implementation Plan.....	2-107
2.3 Obligations of Recipient Country	2-121
2.3.1 General Undertakings to be taken by Cambodia.....	2-121
2.3.2 Specific Undertakings of the Project to be taken by Cambodia.....	2-121
2.4 Project Operation Plan	2-124
2.4.1 Operation and Maintenance Plan for Drainage Facilities.....	2-124
2.4.2 Maintenance Plan for Revetment	2-127

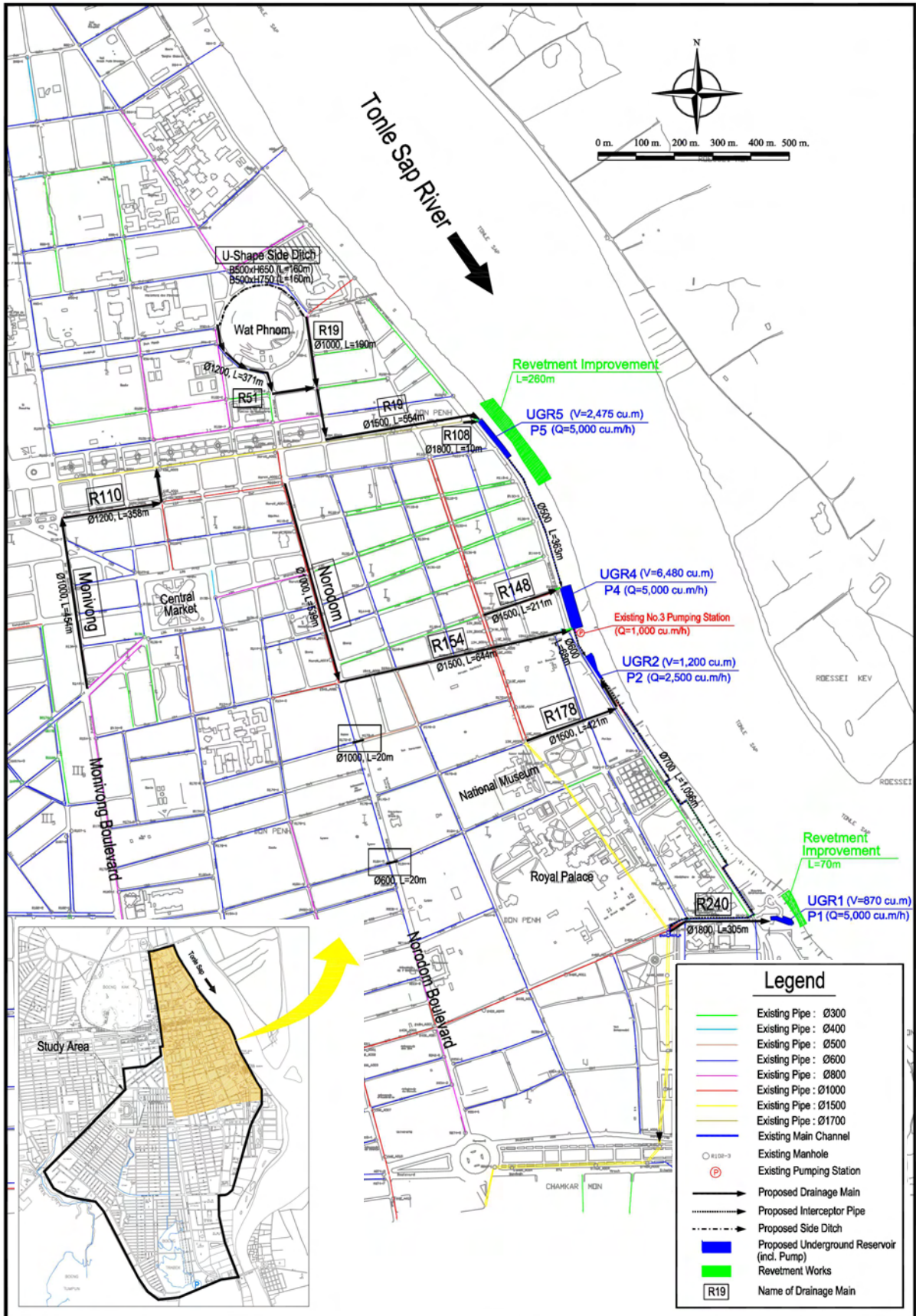
2.5	Project Cost Estimation	2-128
2.5.1	Initial Cost Estimation	2-128
2.5.2	Operation and Maintenance Cost	2-129
2.6	Other Relevant Issues	2-131
CHAPTER 3	PROJECT EVALUATION AND RECOMMENDATIONS	3-1
3.1	Project Effect.....	3-1
3.1.1	Direct Effect	3-1
3.1.2	Indirect Effect.....	3-2
3.2	Recommendations	3-3
3.2.1	Before the Commencement of the Construction Works.....	3-3
3.2.2	During Construction Works	3-3
3.2.3	After Construction Works.....	3-4
3.2.4	Gradual Improvement of Drainage System	3-5
3.2.5	Technology Transfer (Counterpart Training)	3-6

[APPENDICES]

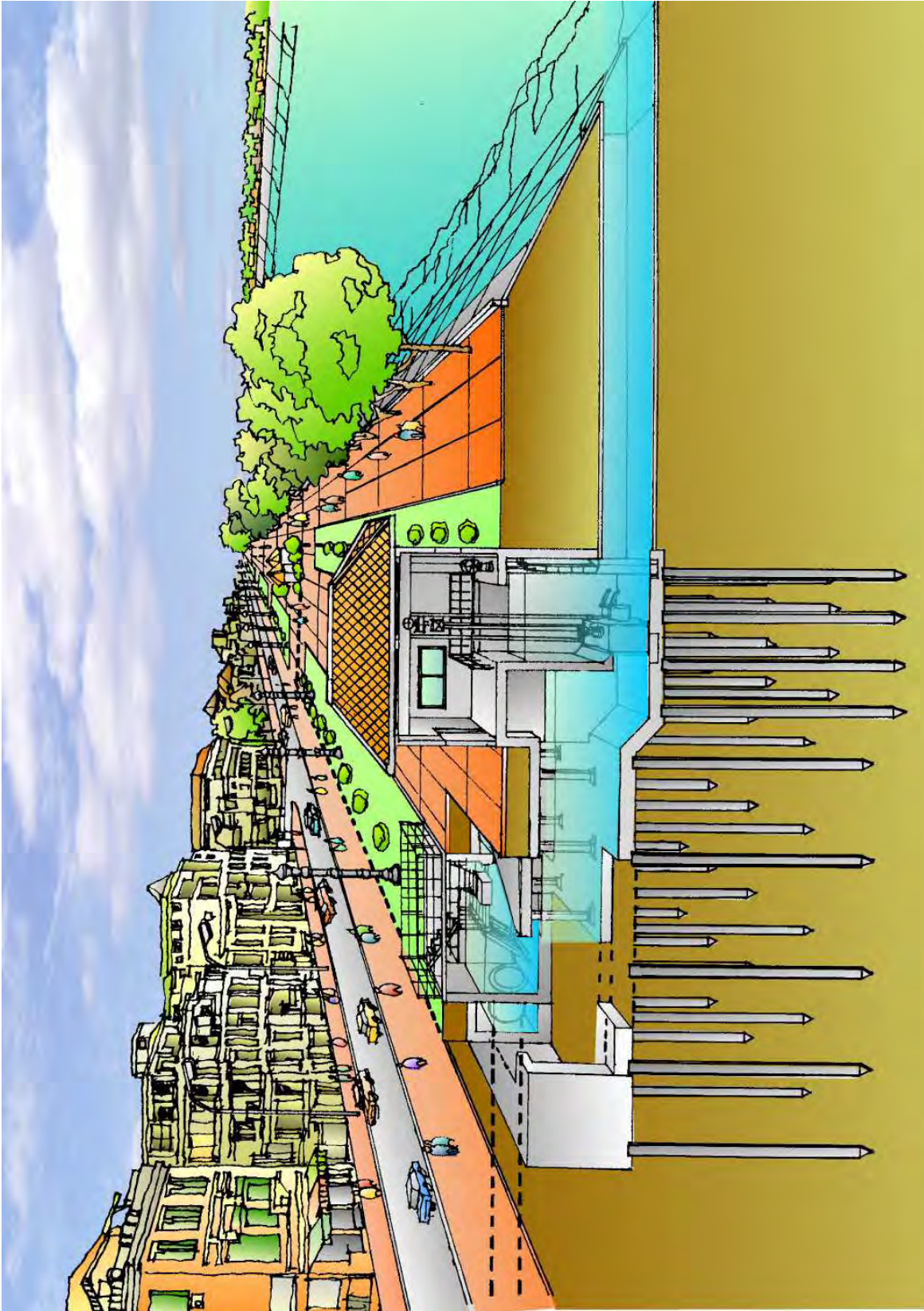
1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussion
5. References



Location Map



Project Area



Perspective (Underground Reservoir No. 4 and Pumping Station No. 4)

LIST OF TABLES

Table 1.2.1	Contents of the Request for Japan's Grant Aid	1-2
Table 1.3.1	Quantities of Topographic Survey	1-4
Table 1.3.2	Results of Boring Survey	1-6
Table 1.3.3	Surveyed Underground Facilities	1-11
Table 1.3.4	Inundation Occurrence of More than Four Times/Year in All Samples (South Area)	1-18
Table 1.3.5	Inundation Depth of Above the Knee in more than 50% Samples (South Area)	1-19
Table 1.3.6	Inundation Time of More than Four Hours in More than 50% of the Samples (South Area)	1-19
Table 1.3.7	Inundation Occurrence of More than Four Times/Year in All Samples (North Area)	1-23
Table 1.3.8	Inundation Depth of Above the Knee in more than 50% Samples (North Area)	1-24
Table 1.3.9	Inundation Time of More than Four Hours in More than 50% of the Samples (North Area)	1-24
Table 2.2.1	Protection Level for Each Facility	2-5
Table 2.2.2	Probable Rainfall	2-5
Table 2.2.3	The Goal of Drainage Improvement Plan	2-16
Table 2.2.4	Contents of the Request and Summary for Evaluation	2-17
Table 2.2.5(1)	The Specification for Drainage Facility of the Request and the Proposed Plan (North Area)	2-19
Table 2.2.5(2)	The Specification for Drainage Facility of the Request and the Proposed Plan (South Area)	2-20
Table 2.2.6	Project Priority	2-23
Table 2.2.7	The Contents of the Proposed Project	2-25
Table 2.2.8	Comparison of Cross Sectional Shape of Old Market East Revetment	2-27
Table 2.2.9	Comparison of Type of Slope Protection Work	2-29
Table 2.2.10	Major Specification of Pumping Station and Underground Reservoir	2-33
Table 2.2.11	Main Configuration of Trash Screen	2-35
Table 2.2.12	Selection of Pump Type	2-40
Table 2.2.13	Basic Dimensions of Pumping Station	2-41
Table 2.2.14	Basic Dimensions of Gate-Mounted Pump	2-41
Table 2.2.15	Floor Elevation of Pump Operation/Maintenance House	2-42
Table 2.2.16	Capacity of Emergency Diesel-Engine Drive Generator Set	2-43
Table 2.2.17	Major Features of R51 Drainage Main	2-46

Table 2.2.18	Major Features of Manhole and Inlet Pipe (R51 Drainage Main)	2-46
Table 2.2.19	Major Features of R19 Drainage Main	2-47
Table 2.2.20	Major Features of Manhole and Inlet Pipe (R19 Drainage Main)	2-48
Table 2.2.21	Major Features of Side Ditch in Wat Phnom Area	2-48
Table 2.2.22	Major Features of Monivong Drainage Main	2-49
Table 2.2.23	Major Features of Manhole and Inlet Pipe (Monivong Drainage Main)	2-50
Table 2.2.24	Major Features of R110 Drainage Main	2-50
Table 2.2.25	Major Features of Manhole and Inlet Pipe (R110 Drainage Main)	2-51
Table 2.2.26	Major Features of R108 Drainage Main	2-51
Table 2.2.27	Major Features of Norodom Drainage Main	2-52
Table 2.2.28	Major Features of Manhole and Inlet Pipe (Norodom Drainage Main)	2-52
Table 2.2.29	Major Features of R154 Drainage Main	2-53
Table 2.2.30	Major Features of Manhole and Inlet Pipe (R154 Drainage Main)	2-53
Table 2.2.31	Major Features of R148 Drainage Main	2-54
Table 2.2.32	Major Features of Manhole and Inlet Pipe (R148 Drainage Main)	2-54
Table 2.2.33	Major Features of R178 Drainage Main	2-56
Table 2.2.34	Major Features of Manhole and Inlet Pipe (R178 Drainage Main)	2-56
Table 2.2.35	Major Features of R240 Drainage Main	2-57
Table 2.2.36	Major Features of Manhole and Inlet Pipe (R240 Drainage Main)	2-57
Table 2.2.37	Design Population	2-58
Table 2.2.38	Calculation of Per Capita Wastewater Discharge	2-58
Table 2.2.39	Summary of Interceptor System	2-59
Table 2.2.40	Quality Control Tests	2-116
Table 2.4.1	DSD Personnel	2-125
Table 2.5.1	Project Cost Borne by Japan's Grant Aid	2-128
Table 2.5.2	Project Cost Borne by Cambodian Government	2-129
Table 2.5.3	Operation and Maintenance Cost before and after the Project	2-129
Table 2.5.4	Annual Operation Cost of New Pumping Stations	2-130

LIST OF FIGURES

Figure 1.3.1	Location of Topographic and Geological Survey	1-5
Figure 1.3.2	Distribution of N-value in Each Borehole	1-7
Figure 1.3.3	Meteorological Data at Pochentong Station (2001-2005)	1-9
Figure 1.3.4	Water Level of Tonle Sap River (2001-2005)	1-10
Figure 1.3.5	Locations of Manhole Survey	1-12
Figure 1.3.6	Result of Interview Survey (Stage I: Interview with Sangkat Chiefs)	1-16
Figure 1.3.7	Target Area and Road of Stage II (Interview with Households)	1-17
Figure 1.3.8	Present Inundation Condition Identified in the Stage II Survey	1-21
Figure 1.3.9	Target Area and Road in North Area	1-26
Figure 1.3.10	Present Inundation Condition Identified in North Area	1-27
Figure 2.2.1	Implementation Section of Revetment Improvement	2-13
Figure 2.2.2	Flowchart to Formulate Drainage Improvement Plan	2-14
Figure 2.2.3	Study Area	2-15
Figure 2.2.4	Location of Project Areas	2-22
Figure 2.2.5	Layout Image of Pumping Station and Underground Reservoir	2-33
Figure 2.2.6	Layout of Underground Reservoir No. 1 and Pumping Station No. 1	2-36
Figure 2.2.7	Layout of Underground Reservoir No. 2 and Pumping Station No. 2	2-37
Figure 2.2.8	Layout of Underground Reservoir No. 4 and Pumping Station No. 4	2-38
Figure 2.2.9	Layout of Underground Reservoir No. 5 and Pumping Station No. 5	2-39
Figure 2.2.10	Alignment of Drainage Main (Wat Phnom Area)	2-46
Figure 2.2.11	Alignment of Drainage Main (Central Market Area)	2-49
Figure 2.2.12	Alignment of Drainage Main (Royal Palace & National Museum Area)	2-55
Figure 2.2.13	Layout of Interceptor Pipe	2-59
Figure 2.2.14	Selection of Temporary Construction Method	2-109
Figure 2.2.15	Implementation Schedule	2-120

LIST OF PHOTOS

Photo 2.2.1	Study Area of the Revetment Improvement Work	2-10
Photo 2.2.2	Collapse in the Old Market East Revetment (1)	2-11

Photo 2.2.3	Collapse in the Old Market East Revetment (2)	2-11
Photo 2.2.4	Chakto Mukh National Theater Revetment	2-12

ABBREVIATIONS

1. ORGANIZATIONS

ADB	: Asian Development Bank
AFD	: Agence Française de Développement
APUR	: Atelier Parisien d'urbanisme (Town Planning Agency for Paris)
BAU	: Bureau des Affaires Urbaines (Bureau of Urban Affairs)
CATUC	: Comité de l'Aménagement du Territoire, d'Urbanisme et de Construction (Committee for Planning, Urbanization and Construction)
CDC	: Council for the Development of Cambodia
CNATUC	: Comité National de l'Aménagement du Territoire, d'Urbanisme et de Construction (National Committee for Country Planning, Urbanization and Construction)
COM	: Council of Ministers
CRDB	: Cambodian Rehabilitation and Development Board
CTA	: Cambodian Telecommunications Authority
DPWT	: Department of Public Works and Transport
DSD	: Drainage and Sewerage Division
EdC	: Electricité du Cambodge
EU	: European Union
GDIMH	: General Directorate of Irrigation, Meteorology and Hydrology of MAFF
GOC	: Government of Cambodia
GOJ	: Government of Japan
JICA	: Japan International Cooperation Agency
MAFF	: Ministry of Agriculture, Forestry and Fisheries
MEF	: Ministry of Economy and Finance
MFAIC	: Ministry of Foreign Affairs and International Cooperation
MOE	: Ministry of Environment
MOP	: Ministry of Planning
MPP	: Municipality of Phnom Penh
MPWT	: Ministry of Public Works and Transport
MWRM	: Ministry of Water Resources and Meteorology
NORAD	: Norwegian Agency for Development Cooperation
PMU	: Project Management Unit
PPWSA	: Phnom Penh Water Supply Authority
TdC	: Telecommunication du Cambodge
UNCHS	: United Nations Centre for Human Settlements
UNDP	: United Nations Development Program
UNESCO	: United Nations Educational, Scientific, and Cultural Organization
UNICEF	: United Nations Children's Fund
UNTAC	: United Nations Transitional Authority in Cambodia
USAID	: United States Agency for International Development
WB	: World Bank
WHO	: World Health Organization

2. OTHER TERMS

A/P	: Authorization to Pay
B/A	: Banking Arrangement
BHN	: Basic Human Need
BOD	: Biochemical Oxygen Demand
BOT	: Built, Operation and Transfer

COD	: Chemical Oxygen Demand
CTS	: Compact Type Transformer Substation
CUDSS	: Cambodian Urban Development Strategy Study
CUEIP	: Cambodian Urban Environmental Improvement Project
DO	: Oxygen Demand
EGS	: Emergency Diesel-Engine Drive Generator Sets
GDP	: Gross Domestic Product
GNI	: Gross National Income
GNP	: Gross National Product
GRDP	: Gross Regional Domestic Product
EPNRM	: Law on Environmental Protection and Natural Resources Management
NPRS	: National Poverty Reduction Strategy
NR	: National Road
NSDP	: National Strategic Development Plan
PAP	: Project Affected Persons
PIP	: Public Investment Plan
SEDP	: Socio-Economic Development Plan
SPT	: Standard Penetration Test
SS	: Suspended Solid
TA	: Technical Assistance

3. UNITS OF MEASUREMENT

(Length)		(Weight)	
mm	: millimeter(s)	mg	: milligram(s)
cm	: centimeter(s)	g, gr	: gram(s)
m	: meter(s)	kg	: kilogram(s)
km	: kilometer(s)	ton	: tonne(s)
(Area)		(Time)	
mm ²	: square millimeter(s)	s, sec	: second(s)
cm ²	: square centimeter(s)	min	: minute(s)
m ²	: square meter(s)	h(hrs)	: hour(s)
km ²	: square kilometer(s)	d(dys)	: day(s)
ha	: hectare(s)	y, yr(yrs)	: year(s)
(Volume)		(Concentration)	
cm ³	: cubic centimeter(s)	mg/ℓ	: milligram per liter
m ³	: cubic meter(s)		
ℓ	: liter(s)		
(Speed/Velocity)			
cm/sec, cm/s	: centimeter per second		
m/sec, m/s	: meter per second		
km/hr, km/h	: kilometer per hour		
(Stress)			
kg/cm ²	: kilogram per square centimeter		
ton/m ²	: ton per square meter		

(Flow/Discharge)

ℓ/sec, ℓ/s	:	liter per second
m ³ /sec, m ³ /s	:	cubic meter per second
m ³ /yr, m ³ /y	:	cubic meter per year

(Electrical Units)

W	:	watt(s)
kW	:	kilowatt(s)
MW	:	megawatt(s)
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
V	:	volt(s)
kV	:	kilovolt(s)

(Note: Other combined units may be constructed similarly as above)

4. MONETARY TERMS

¥	:	Japanese Yen
US\$:	United States Dollar
Riel	:	Cambodian Riels

5. CAMBODIAN TERMS

Boeng	:	Lake
Prek	:	River/Stream
Stoeng	:	River (medium)
Tonle	:	River (large)